U.S. Department
of Transportation
**Pipeline and
Hazardous Materials
Safety Administration**

East Building, PHH-23
1200 New Jersey Ave., SE
Washington, D.C. 20590

COMPETENT AUTHORITY CERTIFICATION
FOR A TYPE AF FISSILE
RADIOACTIVE MATERIALS PACKAGE DESIGN
CERTIFICATE USA/0653/AF-96, REVISION 4

REVALIDATION OF FRENCH COMPETENT AUTHORITY CERTIFICATE F/381/AF-96

This certifies that the radioactive material package design described is hereby approved for use within the United States for import and export shipments only. Shipments must be made in accordance with the applicable regulations of the International Atomic Energy Agency[1] and the United States of America[2].

1. Package Identification - TNF-XI

2. Package Description and Authorized Radioactive Contents - as described in French Certificate of Competent Authority F/381/AF-96 Bc dated July 4, 2007 (attached) subject to the following restrictions:

   a. Type and Form of Material: Uranium oxide pellets, powder and scrap meeting the requirements of Enriched Commercial Grade Uranium, as defined in ASTM C996-96. U_3O_8 or $UO_{x,\ x\geq 2}$ are authorized provided the equivalent UO_2 mass is less than the limits specified below:

Max ^{235}U Enrichment (weight percent)	Homogenous UO_2 Powder Maximum Loading (kg)	Heterogenous UO_2 Pellet Maximum Loading (kg)
$\leq$ 4.05	300	300
4.1	300	293
4.15	300	287
4.25	300	271
4.35	300	259
4.45	300	247
4.55	294	238
4.65	281	228
4.75	265	219
4.85	255	208
4.95	244	202
5.0	239	197

   b. Maximum quantity of material: No more than 25 kg of contents per pail and no more than 300 kg of contents per package.

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[1] "Regulations for the Safe Transport of Radioactive Materials, 1996 Edition (Revised)", No. TS-R-1 (ST-1, Revised)," published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Parts 100 - 199, United States of America.

3. Criticality - The minimum criticality safety index is 0.5. The maximum number of packages per conveyance is determined in accordance with Table X of the IAEA regulations cited in this certificate.

4. General Conditions -

   a. Each user of this certificate must have in his possession a copy of this certificate and all documents necessary to properly prepare the package for transportation. The user shall prepare the package for shipment in accordance with the documentation and applicable regulations.

   b. Each user of this certificate, other than the original petitioner, shall register his identity in writing to the Office of Hazardous Materials Technology, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.

   c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

   d. Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations[1] shall be maintained and made available to authorized officials for at least three years after the last shipment authorized by this certificate. Consignors exporting shipments from the United States shall satisfy the requirements of Subpart H of 10 CFR 71.

5. Special Conditions -

   a. Except for package markings, labels, placards and determination of the transport index, the package shall be prepared for shipment and operated in accordance with the operating procedures approved by the U.S. Nuclear Regulatory Commission (attached). Package markings, labels, placards and determination of the transport index shall be in accordance with the IAEA regulations and the provisions of this certificate.

   b. Each packaging must be acceptance tested and maintained in accordance with the Acceptance Tests and Maintenance Program approved by the U.S. Nuclear Regulatory Commission (non proprietary version attached - proprietary version available from applicant).

   c. Prior to each shipment, the stainless steel components of the packaging must be visually inspected. Packagings in which stainless steel components show pitting corrosion, cracking, or pinholes are not authorized for transport.

   d. All shipments shall use the proper shipping name "RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSILE, non-special form" (UN 3327).

6. Marking and Labeling - The package shall bear the marking USA/0653/AF-96 in addition to other required markings and labeling. Marking with NRC assigned identification number is not required.

CERTIFICATE USA/0653/AF-96, REVISION 4

7. Expiration Date - This certificate expires on December 31, 2011. Upon issuance, this certificate supersedes all previous editions of USA/0653/AF-96.

This certificate is issued in accordance with paragraph 814 of the IAEA Regulations and Section 173.472 and 173.473 of Title 49 of the Code of Federal Regulations, in response to the May 30, 2007 petition by Packaging Technology, Tacoma, WA and in consideration of other information on file in this Office.

Certified by:

Bob Richard
Deputy Associate Administrator for Hazardous Materials Safety

JUL 23 2007
(DATE)

Revision 4 - Issued to revalidate French Certificate of Approval No. F/381/AF-96, Revision Bc, dated July 4, 2007 with restricted contents and specified operating, acceptance, test, and inspection procedures.

The French competent authority,

Given the application submitted by the TN International company in the letter S/06-132 of December 15th, 2006;

Given the TN International Safety Analysis Report DOS-06-00037028-000 Rév.0 of December 12th, 2006,

certifies that the package design called "TNF-XI", as described in appendix 0 index c and:

- Loaded with oxides of uranium, unirradiated, enriched to a maximum of 10 % in ^{235}U as described in appendices 1c and 2c,

complies, as a Type A package with fissile materials,

with the requirements of the regulations, agreements or recommendations listed below:
- Safety Standards Series– Regulations for the Safe Transport of Radioactive Materials – International Atomic Energy Agency n° TS-R-1 (2005 Edition),
- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR),
- Regulations concerning the International carriage of Dangerous goods by Rail (RID),
- Regulations for the Carriage of Dangerous Goods on the Rhin (ADNR),
- International Maritime Dangerous Goods Code (IMDG Code from OMI),
- Decree of June 1st, 2001 modified concerning the carriage of dangerous goods by road (Decree ADR),
- Decree of June 5th, 2001 modified concerning the carriage of dangerous goods by rail (Decree RID),
- Decree of December 5th, 2002 modified concerning the carriage of dangerous goods by inland waterway (Decree ADNR),
- Decree of November 23th, 1987 modified concerning the Ship Safety, section 411, attached (Decree RSN).

This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.

This certificate expires on **December 31st, 2011**.

Registration number: **ASN/DIT/0364/2007**

Paris, July 04th, 2007

For the President of ASN and by delegation
The assistant general manager

Jean-Luc LACHAUME

SUMMARY OF CERTIFICATE ISSUES

Issue	Expiration	Type of issue and modifications	Authority	Type of certificate	Revision index						
						t	0	1	2	3	4
05.08.02	05.08.07	First issue type A and type IP-2 package	DGSNR	AF-96	Aa	-	a	a	a	a	a
31.10.02	05.08.07	Extension type A and type IP-2 package	DGSNR	AF-96	Ab	-	b	b	b	b	b
04.07.07	31.12.11	Prorogation type A package	ASN	AF-96	Bc	-	c	c	c	-	-
04.07.07	31.12.11	Prorogation type IP-2 package	ASN	IF-96	Bd	-	d	-	-	d	d

APPENDIX 0
TNF-XI PACKAGING

1. DESCRIPTION OF THE PACKAGING

The packaging is designed, manufactured, inspected, tested, maintained and used in compliance with the Safety Analysis Report TN International DOS-06-00037028-000 Rév. 0 of December 12th, 2006.

The TNF-XI packaging, of a generally rectangular shape, is presented in Figure 0.1.

The design drawing of the packaging is the drawing COGEMA LOGISTICS 12986-01 Rév. I.

The outer overall dimensions of the packaging are:

- Nominal height of body: 940 mm,
- Maximal nominal height of packaging: 1040 mm,
- Cross section of body: 1100 × 1100 mm (overall nominal dimensions)

The maximal weight of empty packaging (± 10 kg) is 660 kg.
The maximal weight of loaded packaging allowable in transport is 1050 kg.

The packaging comprises the main components described below.

1.1 Body

The body of the packaging consists of a steel external casing of rectangular shape, and four cylindrical internal wells, also made of steel, separated by a layer of shock-absorbing and thermally insulating material.

Each well consists of two steel shells separated by a filling of neutron shielding material. The natural boron concentration of this material is compliant with the value specified in chapter 0 of Safety Analysis Report.

1.2 Closing device

Each well is closed by a primary lid equipped with an elastomer gasket. The internal face is equipped with four steel teeth enabling closing on the well flange by a "bayonet system".

The primary lid is protected by an upper plug formed by the superimposing of discs. This assembly is surrounded by a thin steel covering. The upper face comprises six steel teeth enabling closing on the body flange by a "bayonet system". Leaktightness between the plug and the body is provided by a seal.

1.3 Handling and storage components

The lower face of the packaging is equipped with steel forklift paths.

1.4 Safety functions

The main safety functions and the most important elements for safety are:

- **the containment** provided by the containment system constituted of:
  - the four stainless steel cylindrical inner shells;
  - the four flat stainless steel bottoms welded to the cylindrical inner shells;
  - the four primary lids and their seals;
- **the radiological shielding** mainly provided by:
  - the resin contained between the cylindrical inner and outer shells;
  - the foam in the packaging body;
  - the steel sheets contained in the primary lids, the inner shells, the four cylindrical inner and outer shells;
  - the boronated steel sheets;
  - the discs near the upper plugs;
- **the safety criticality** provided the confinement system constituted of the elements described in chapter 0 of the safety analysis report;
- **the protection against shock** is mainly provided by the shock absorber material contained in the body of the packaging;
- **the protection against fire** mainly provided by insulating material.

2. MEASURES TO BE TAKEN BY CONSIGNOR BEFORE SHIPMENT

The package must be used in compliance with the operating instructions of the Safety Analysis Report described in chapter 6A.

3. MAINTENANCE PROGRAM

The maintenance program of the packaging is described in chapter 7A of the Safety Analysis Report.

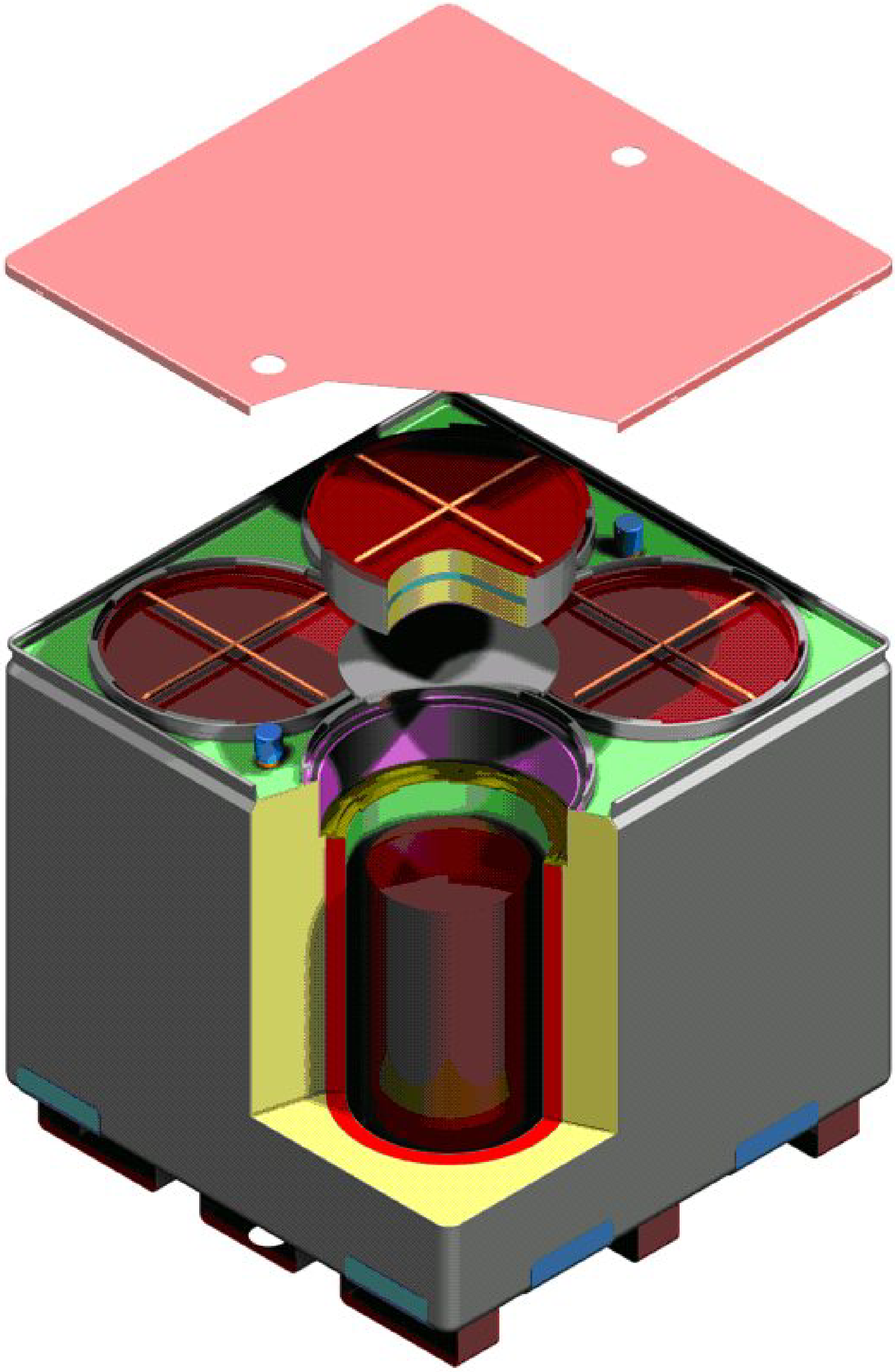
4. NOTIFICATION AND REGISTRATION OF SERIAL NUMBERS

Should a packaging be disposed of or change ownership, this must be notified to the competent authorities. Accordingly, the party relinquishing ownership of a packaging shall forward the name of the new owner.

5. QUALITY ASSURANCE

The applicable quality assurance principles for the packaging design, manufacture, inspection, tests, maintenance and use must be compliant with these described in chapter 8A of the Safety Analysis Report.

FIGURE 0.1
SKETCH OF THE TNF-XI PACKAGE



APPENDIX 1

CONTENT N° 1

TYPE A PACKAGE WITH FISSILE MATERIALS

POWDER OF UO_2, UO_3, OR U_3O_8, OR PELLETS OR SCRAPS OF UO_2, OF ENRICHED URANIUM UNIRRADIATED, WITH VARIABLE MASS ENRICHMENT UP TO 10 % IN ^{235}U

1. AUTHORIZED CONTENT DEFINITION

1.1 Physical form

The radioactive content is constituted of powder of UO_2, UO_3, or U_3O_8, or pellets or scraps of UO_2.

1.2 Isotopic composition and maximal allowable weight

The maximal allowable weight of uranium oxide in each cavity (shared out in the three primary containers (or pails)) of the packaging is limited to the values defined in function of the content enrichment in ^{235}U, as follows:

Mass enrichment ($e = {}^{235}U.U_{tot}$)	Powder	Pellets and scraps
$e \leq 4.1\%$	75 kg	75 kg
$4.1\% < e \leq 4.4\%$		75 kg
$4.4\% < e \leq 4.6\%$		72.5 kg
$4.6\% < e \leq 4.7\%$		68.0 kg
$4.7\% < e \leq 4.8\%$		65.0 kg
$4.8\% < e \leq 4.9\%$		62.5 kg
$4.9\% < e \leq 5\%$		60.0 kg
$5\% < e \leq 10\%$	17.5 kg	/
Density	≤ maximal theoretical density (11)	

1.2 Maximal activity

The radioactive content must comply with the criterions of “unirradiated Uranium” of the applicable regulation.

1.3 Maximal weight of powder

The maximal total weight of this content is 300 kg.

2. PACKAGING

Inner containers: primary containers (or pails)

The content is put in primary pails (three per each of the four cavities) in stainless steel of type defined by the drawing NFI-NK97-002-0100 or defined by the drawing NFI-E215509, or in primary containers in steel without any blunt part different from these ones described in the preceding drawings, and subject to an authorisation beforehand of the competent authority.

The internal primary containers are stacked in vertical position in the cavity of the packaging. Each container has to contain a boronated steel ring, with a minimal height of 180 mm, a minimal thickness of 2 mm and a minimal external diameter of 280 mm, of which the boron mass content must be greater than the value specified in chapter 0A of the Safety Analysis Report.

Each cavity must always contain the three pails with their boronated ring.

Materials containing more hydrogen than water are not authorized in the free gaps of the package.

3. CRITICALITY ANALYSIS

It is taken from chapter 5A of the Safety Analysis Report TN International DOS-06-00037028-000 Rev.0 of December 12th, 2006.

Confinement system considered is described in chapter 0 of the Safety Analysis Report TN International DOS-06-00037028-000 Rev.0 of December 12th, 2006.

Criticality Safety Index (CSI): 0

APPENDIX 2

CONTENT N° 2

TYPE A PACKAGE WITH FISSILE MATERIALS

POWDER (POSSIBLY GRANULATED WITH A RADIUS OF 1 MM) OF UO_2, UO_3, OR U_3O_8, OF ENRICHED URANIUM UNIRRADIATED, WITH VARIABLE MASS ENRICHMENT UP TO 10 % IN ^{235}U

1. AUTHORIZED CONTENT DEFINITION

1.1 Physical form

The radioactive content is constituted of powder (possibly granulated with a radius of 1 mm) of UO_2, UO_3, or U_3O_8.

1.2 Isotopic composition and maximal allowable weight

The maximal allowable weight of uranium oxide in each cavity (shared out in three primary containers (or pails)) of the package is limited to the values defined in function of the content enrichment in ^{235}U, as follows:

Mass enrichment ($e = {}^{235}U.U_{tot}$)	Granulated powder Radius of 1 mm maximum
$e \leq 4.1\%$	75 kg
$4.1\% < e \leq 4.4\%$	
$4.4\% < e \leq 4.6\%$	
$4.6\% < e \leq 4.7\%$	70.0 kg
$4.7\% < e \leq 4.8\%$	67.5 kg
$4.8\% < e \leq 4.9\%$	65.0 kg
$4.9\% < e \leq 5\%$	62.5 kg
$5\% < e \leq 10\%$	15.95 kg
Density	≤ theoretical maximal density

1.3 Maximal activity

The radioactive content must comply with the “unirradiated Uranium” definition of the applicable regulation.

1.3 Maximal weight of powder

The total maximal weight of this content is 300 kg.

2. PACKAGING

Inner containers: primary containers (or pails)

The content is put in primary pails (three per each of the four cavities) in stainless steel of type defined by the drawing NFI-NK97-002-0100 or defined by the drawing NFI-E215509, or in primary containers in steel without any blunt part different from these ones described in the preceding drawings, and subject to an authorisation beforehand of the competent authority.

The internal primary containers are stacked in vertical position in the cavity of the packaging. Each container has to contain a boronated steel ring, with a minimal height of 180 mm, a minimal thickness of 2 mm and an minimal external diameter of 280 mm, of which the boron mass content must be greater than the value specified in chapter 0A of the Safety Analysis Report.

Each cavity must always contain the three pails with their boronated ring.

Materials containing more hydrogen than water are not authorized in the free gaps of the package.

3. CRITICALITY ANALYSIS

It is taken from chapter 5A of the Safety Analysis Report TN International DOS-06-00037028-000 Rev.0 of December 12th, 2006.

Confinement system considered is described in chapter 0 of the Safety Analysis Report TN International DOS-06-00037028-000 Rev.0 of December 12th, 2006.

Criticality Safety Index (CSI): 0

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

Per the requirements of 10 CFR §71.85(c)[1], this section discusses the inspections and tests to be performed prior to first use of the TNF-XI package.

8.1.1 Visual Inspections

All TNF-XI packaging materials of construction and welds shall be examined in accordance with the requirements delineated on the drawings in Appendix 1.3.1, *Packaging General Arrangement Drawings*, per the requirements of 10 CFR §71.85(a).

8.1.2 Structural and Pressure Tests

8.1.2.1 Lift/Tie-down Device Load Testing

The TNF-XI packaging does not contain any lifting/tiedown devices that require load testing.

8.1.2.2 Containment Vessel Pressure Testing

Per the requirements of 10 CFR §71.85(b), no pressure testing is required because the maximum normal operating pressure is less than 35 kPa. (See paragraph 3.4.1).

8.1.3 Fabrication Verification Leak Tests

The TNF-XI packaging does not contain any seals or containment boundaries that require leak testing.

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[1] Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Material*, 1-1-98 Edition.

8.1.4 Component Tests

8.1.4.1 Phenolic Foam

This section establishes the requirements and acceptance criteria for production, installation, inspection, and testing of the rigid, open-celled, phenolic foam utilized within the TNF-XI packaging. The detailed procedures for production and testing of the phenolic foam are given the Transnucleaire specification contained in Section 8.3. These procedures ensure that the foam has the specified physical, chemical, thermal, mechanical, and dimensional properties summarized as follows:

- All foam items are M1-F1 phenolic foam. The chemical composition is [redacted] water and [redacted] dry foam. The minimum content of Hydrogen is [redacted] by mass. The other constituents are Carbon ([redacted] by mass) and oxygen ([redacted] by mass).
- Foam densities are summarized in the table below and are calculated from the sample mass and the displaced volume after placing it in water. The density includes at least [redacted] water.
- Compressive strengths are summarized in the table below and are verified per ISO 844.
- To protect against corrosion of the package's structural components, all foam items must have a leachable chloride content less than 20 ppm as per the CNRS/WICKBOLD method.
- All foam has a thermal conductivity [redacted] W/m/K at 20°C, dry.
- All foam is classified as M1 fire-resistant per NF P 92-501 meaning that the foam self-extinguishes after undergoing an oven test.
- All steel surfaces are brushed, cleaned, and degreased prior to installation or pouring of foam.

Table 8-1. Properties of Foam Items

Item No.	Foam Density (kg/m^3) at 20°C	Compressive Strength at 50% Crushing at 20°C (MPa)	Fabrication Techniques (See Appendix 8.3)
15	[redacted] (type3)	[redacted]	molded
23	[redacted] (type1)	[redacted]	molded
24	[redacted] (type1)*	[redacted]	poured
22	[redacted] (type2)	[redacted]	molded
44**	[redacted] (type2)	[redacted]	molded

Notes:
* Because item 24 is poured, during fabrication its density is verifed indirectly by measuring its mass ([redacted]) and comparing it to the volume of the foamed space (487 liters).
** Item 44 is referred to as Item 24-1 in Appendix 8.3

Qualification of the foam:

The qualification test of the foam parts is described in Section 8.3.

8.1.4.2 Neutron Poison

This section establishes the requirements and acceptance criteria for inspection and testing of neutron poison utilized within the TNF-XI packaging. Two neutron poisons are utilized for this package, borated stainless steel and BORA resin. For both neutron poison materials, the criticality analysis in Chapter 6 assumes that the Boron credit is 75% of the minimum Boron concentration stipulated on the design drawings.

8.1.4.2.1 Borated Stainless Steel

All borated stainless steel meets the requirements of ASTM A 887-89 Type 304B4 Grade B. The borated stainless steel disks in the cavity and in the shield plugs are fabricated to Böhler Bleche specification A976SC. Because all borated stainless steel is supplied, the supplier of this material performs all qualification and acceptance testing of this material. The fabricator receives only material that has been certified according to the applicable standards. For completeness, the acceptance testing used by the supplier for the borated stainless steel is provided below.

Borated stainless steel disk acceptance tests (performed by supplier):

Stainless steel disks will be cut from “parent–plates” which are manufactured according to ASTM A 887-89 for type 304B4 material. Additionally, each “parent-plate” will undergo an acceptance test to demonstrate the desired neutron absorption capability of the sheets.

The principle of the test is to measure the reduction of the neutron flux caused by the Boron alloyed in the material. The test device containing a neutron source is placed on the test article, which is situated on a reflector table. An impulse counter in the test device measures the count rate for a period of time depending on the Boron content, thickness of the material, and the power of the neutron source. The supplied plates will be tested such that:

- 2.5% of the “parent-plates” from which stainless steel disks are cut will be tested using multiple points on a grid, to demonstrate the Boron uniformity.
- 97.5% of the "parent-plates" will be tested at one random location on the plate.

Rejection of a parent-plate will occur if it does not meet the specified criteria. Only conforming plate material will be supplied to the fabricator.

The acceptance criteria for testing of the borated stainless steel plate is based on the minimum Boron content of the plate (B_{min}) and the plate's minimum thickness (th_{min}).

- A reference test piece is cut from one sheet of the order, and the Boron content of the reference test piece is measured by chemical analysis (B_{ref}).
- The absolute minimum of the Boron content in the reference test piece (B_{ref_min}) is calculated by subtracting twice the standard deviation of boron homogeneity from the boron content measured above. The standard deviation of boron homogeneity is provided by the material supplier and is based on historical data. Thus, the absolute minimum of the Boron content corresponds to the lower bound of Boron content with 95% probability.
- The reference thickness is determined by the equation:

  $$th_{ref} = B_{min} \times th_{min} / B_{ref\_min}$$

- The reference piece is then machined is grounded to the reference thickness.
- The neutron absorption capacity of the reference piece is then analyzed by measuring the count rate (CR) with the same test equipment and procedure used to measure the CR in the acceptance tests. However, 50 measurements are to be taken at one location so that an average value (CR_{ref_mean}) and the standard deviation (S_{CR_ref}) can be calculated.
- The acceptance limit for the count rate during acceptance testing must be less than or equal to:

  $$CR \leq CR_{ref\_mean} - 2\ S_{CR\_ref}$$

  Thus, the acceptance limit corresponds to the lower bound of the count rate with 95% confidence in the acquisition of the count rate data.

8.1.4.2.2 BORA Resin

BORA resin is a rigid polyester based compound with a high natural boron content having a minimum density of 1.75 g/cm^3. The mass percentage of the compounds used to make the resin is listed in Table 8-2. Additionally, small amounts of catalyst and accelerator are used to initiate and accelerate the polymerization.

Table 8-2. BORA Resin Composition

Component	Mass Percentage
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

For the boron carbide, the particles are between [redacted] µm and [redacted] µm in size. For the zinc borate, the average particles size is [redacted] µm, and the maximum size [redacted] µm. The discussion below regarding qualification testing of the resin shows that the particle concentration is uniform in the shell.

Material properties are documented in Section 8.4. The resin is mixed in a liquid form before pouring it into special molds. After polymerization, the shell is mounted onto the identified cavity.

<u>BORA resin qualification process:</u>

During the development of the product, material properties were characterized as a function of temperature, including the effect of temperature on material durability (see Section 8.4). Because this package is designed to handle fresh powder, the radiation environment is not severe enough to affect the material properties. For this reason, the effects of the radiation environment on the materials were not considered.

The qualification of the pouring of BORA resin is performed with the mold intended for use in the manufacturing process and by qualified operators, prior commencing manufacturing. In addition, a separate "test sample" is poured for each shell that is fabricated. Each shell/test sample is poured from a unique batch so that non-conformity in a shell does not impact other shells.

Qualification of BORA resin manufacturing process will occur if:

- The mass of each compound used in making the resin is within ±0.5% of its nominal mass.

- The BORA resin shell meets the dimensional inspection criteria (thickness and height).
- The BORA resin shell meets the density criteria.

  Samples are taken at multiple locations in the top, middle, and bottom of the shells as well as the "test sample" that is made at the end of the pour. The "test sample" corresponds to the sample that will be used for conducting the acceptance test. All specimens must meet the minimum density requirement ([redacted] g/cm^3) in order for qualification to occur. Qualification test data is provided in Table 8-3.

- The BORA resin shell meets the Boron content requirements as measured by mass spectroscopy given that the concentration of B-10 in natural Boron is 19.9 atom-percent (18.43 wt-%).
- Test specimens are cut from a qualification test shell at multiple locations. First, the density of each test specimen is measured. Next, the percentage of Boron content is measured by mass spectroscopy. All test specimens must meet the minimum resin density ([redacted] g/cm3) and minimum Boron percentage ([redacted] requirements in order for qualification to occur. Qualification test data are provided in Table 8-4.
- The BORA resin shell meets the minimum Boron content determined by calculation.

The above tests show that:

- The proper amount of natural boron (and B-10) is in each pour.
- The resin density and the natural boron (and B-10) content is uniform in each shell.

Thus, ensuring the minimum resin density, proper material dimensions, the minimum Boron content, and homogeneity of the Boron, guarantee that the resin will have the proper B-10 number density of [redacted] B^{10}/b-cm.

Additionally, the tests show that the test sample is appropriate to use for the verification of density during acceptance testing.

Table 8-3. Qualification Test Data

Qualification Test Article	Calculated % Boron*	Measured Average Density**	
24	[redacted]	Top	[redacted]
		Middle	[redacted]
		Bottom	[redacted]
		Test Sample	[redacted]
25	[redacted]	Top	[redacted]
		Middle	[redacted]
		Bottom	[redacted]
		Test Sample	[redacted]
26	[redacted]	Top	[redacted]
		Middle	[redacted]
		Bottom	[redacted]
		Test Sample	[redacted]

*Natural Boron content. Calculated from the masses of the compounds used to mix the resin. The B-10 content is equal to 18.43% of natural Boron content.

**average density is the average of 3 samples at shell location and 1 sample for the casting sample

Table 8-4. Mass Spectroscopy Qualification Test Results (from Test Report 12986-R-10, Rev 0, see Section 8.5)

Base Sample	B-nat* (%)	Measured Density (g/cm^3)	Middle Sample	B-nat* (%)	Measured Density (g/cm^3)	Top Sample	B-nat* (%)	Measured Density (g/cm^3)
B1a	[redacted]	[redacted]	M1a	[redacted]	[redacted]	H1a	[redacted]	[redacted]
B1b	[redacted]	[redacted]	M1b	[redacted]	[redacted]	H1b	[redacted]	[redacted]
B2a	[redacted]	[redacted]	M2a	[redacted]	[redacted]	H2a	[redacted]	[redacted]
B2b	[redacted]	[redacted]	M2b	[redacted]	[redacted]	H2b	[redacted]	[redacted]
B3a	[redacted]	[redacted]	M3a	[redacted]	[redacted]	H3a	[redacted]	[redacted]
B3b	[redacted]	[redacted]	M3b	[redacted]	[redacted]	H3b	[redacted]	[redacted]
B4a	[redacted]	[redacted]	M4a	[redacted]	[redacted]	H4a	[redacted]	[redacted]
B4b	[redacted]	[redacted]	M4b	[redacted]	[redacted]	H4b	[redacted]	[redacted]
Average	[redacted]		Average	[redacted]		Average	[redacted]	

* The B-10 content is equal to 18.43% of natural Boron content.

BORA resin qualification at low temperature conditions:

The chemical properties of the BORA resin do not change under cold temperature, only the mechanical characteristics such as the compression modulus which increases in cold conditions. Thus, it has no impact on the TNF-XI package design.

Additionally, the thermal expansion of the BORA resin material is [redacted] K^{-1}. The change in thickness of the shell (34 mm thick) in cold conditions is equal to:

h = [redacted] × (20 - (-29)) × 34 = [redacted] mm

This small change in thickness will not change the B-10 areal density in the shell.

BORA resin qualification at normal conditions:

The maximum temperature of the BORA resin shell in normal conditions of transport is 62°C (Section 3.6.2, Figure 5) including the effects of insolation.

During the qualification of the resin, a resin sample (25×35×100 mm) was weighed after being heated to a temperature of 50°C for 4032 hours (168 days).

The loss of mass measured after the heating period was approximately [redacted]

Conservatively it is assumed that this loss of mass is due to water evaporation. The atomic mass ratio of hydrogen in water is :

Hydrogen : 2 / 18 = 11.11 %

Then, the loss of hydrogen is equal to:

[redacted]

This means that the hydrogen content in the BORA resin, at minimum equal to [redacted] (according to Section 1.2.1.3), is reduced to [redacted] which is negligible. Recall that in manufacturing, the density is at least [redacted] g/cm^3 whereas criticality calculations were performed with [redacted] g/cm^3.

The minimum density requirement allows a decrease in hydrogen to: [redacted]. Thus, conservatively assuming a maximum loss in hydrogen content, the required hydrogen concentration will be present in the resin.

BORA resin acceptance tests:

The quantity of Boron in the resin are checked to ensure that the concentrations exceed those used in the criticality studies (see chapter 6 of this Safety Analysis Report). Shells that do not conform to prescribed mass, density, or dimensional requirements are rejected.

Each BORA resin shell will be manufactured with qualified molds and each shell will be verified for:

- Component mass: Each component mass must be within ±0.5% of its nominal mass
- Dimensional requirements: minimum thickness, as well as height, to ensure complete coverage when the shell is placed between the inner and outer shells of the inner well.
- Density: direct measuring of the resin density of 3 specimens is taken from the test sample. The minimum acceptable density from acceptance testing ([redacted] g/cm^3) is greater than the minimum density assumed for the material ([redacted] g/cm^3). Density measurements cannot be

made on the shell itself because the test is destructive. Qualification test data indicates homogeneity between test sample and the corresponding shell.

- Natural Boron content: calculated from measuring the mass of the components used in making the resin. Given the percentage of natural Boron in the sample, the amount of B-10 can be determined given there is 19.9 atom-percent (18.43 wt-%) of B-10 in natural Boron.

The satisfaction of these requirements guarantee that the BORA resin shell has the proper B-10 density of [redacted] B^{10}/b-cm. Each resin shell is fabricated from a unique batch of resin. Thus, failure of the shell to meet the specified criteria results in the rejection of only that particular shell.

A sampling of data from existing shell acceptance tests is provided in Table 8-5 for verification with 95% confidence that the calculated Boron concentration and the minimum resin density specified in the acceptance test procedure are greater than the required minimum values. The 36 data points are taken from shells made both early (casting number from 96 to 115) and later (casting number from 1179 to 1235) in the manufacturing process. This shows that the 95% confidence is valid over time.

Table 8-5. BORA Resin Acceptance Test Data

	Casting No	Calculated % Boron-natural	Measured Average Density (g/cm^3)
1	96	[redacted]	[redacted]
2	98	[redacted]	[redacted]
3	100	[redacted]	[redacted]
4	103	[redacted]	[redacted]
5	97	[redacted]	[redacted]
6	99	[redacted]	[redacted]
7	95	[redacted]	[redacted]
8	91	[redacted]	[redacted]
9	105	[redacted]	[redacted]
10	107	[redacted]	[redacted]
11	111	[redacted]	[redacted]
12	112	[redacted]	[redacted]
Sample Size (n)		12	12
Average		[redacted]	[redacted]
Standard Deviation (σ)		[redacted]	[redacted]
95% Probability (2σ)		[redacted]	[redacted]
95% Lower Bound**		[redacted]	[redacted]
Minimum allowable		[redacted]	[redacted]

Table 8-5 (continued). BORA Resin Acceptance Test Data

	Casting No	Calculated % Boron-natural	Measured Average Density (g/cm^3)
13	146	[redacted]	[redacted]
14	144	[redacted]	[redacted]
15	143	[redacted]	[redacted]
16	139	[redacted]	[redacted]
17	129	[redacted]	[redacted]
18	120	[redacted]	[redacted]
19	113	[redacted]	[redacted]
20	119	[redacted]	[redacted]
21	135	[redacted]	[redacted]
22	134	[redacted]	[redacted]
23	118	[redacted]	[redacted]
24	115	[redacted]	[redacted]
Sample Size (n)		12	12
Average		[redacted]	[redacted]
Standard Deviation (σ)		[redacted]	[redacted]
95% Probability (2σ)		[redacted]	[redacted]
95% Lower Bound**		[redacted]	[redacted]
Minimum allowable		[redacted]	[redacted]
25	1205	[redacted]	[redacted]
26	1211	[redacted]	[redacted]
27	1212	[redacted]	[redacted]
28	1214	[redacted]	[redacted]
29	1204	[redacted]	[redacted]
30	1229	[redacted]	[redacted]
31	1228	[redacted]	[redacted]
32	1235	[redacted]	[redacted]
33	1213	[redacted]	[redacted]
34	1208	[redacted]	[redacted]
35	1199	[redacted]	[redacted]
36	1179	[redacted]	[redacted]
Sample Size (n)		12	12
Average		[redacted]	[redacted]
Standard Deviation (σ)		[redacted]	[redacted]
95% Probability (2σ)		[redacted]	[redacted]
95% Lower Bound**		[redacted]	[redacted]
Minimum allowable		[redacted]	[redacted]

*Each density is the average of that measured from three specimen from each casting sample

**The lower bound determined from acceptance test data is greater than the larger of the two lower bounds determined during qualification testing ([redacted]). Thus, the qualification tests bound the acceptance test data.

8.1.5 Test for Shielding Integrity

The TNF-XI package does not contain any biological shielding.

8.1.6 Thermal Acceptance Tests

The material properties utilized in Chapter 3.0, *Thermal*, are consistently conservative for the Normal Conditions of Transport (NCT) thermal analysis performed. The Hypothetical Accident Condition (HAC) fire certification testing of the TNF-XI package (see Section 2.10.1, *Certification Tests*) served to verify material performance in the HAC thermal environment. As such, with the exception of the tests required for specific packaging components, as discussed in Section 8.1.4, *Component Tests*, specific acceptance tests for material thermal properties are not required or performed.

8.2 MAINTENANCE PROGRAM

8.2.1 Structural and Pressure Tests

8.2.1.1 Weight Verification

Verification of the package's empty mass must occur within three years prior to a shipment or within the last 15 transports (whichever is in a shorter amount of time), to ensure that no water in-leakage has occurred in the foam region of the package.

8.2.1.2 Surface Inspection

Visual inspection shall be performed on the visible surfaces of the package exterior, plugs, lids, and cavities for indications of chemically induced corrosion, within three years of a shipment or within the last 15 transports (whichever is in a shorter amount of time). This ensures that degradation such as pitting or through wall corrosion has not taken place.

8.2.1.3 Lifting/Tie-down Device Load Testing

The TNF-XI package does not contain any lifting/tie-down devices that require load testing.

8.2.1.4 Containment Boundary Pressure Testing

No pressure tests are necessary to ensure continued performance of the TNF-XI packaging.

8.2.2 Leak Tests

No leak tests are necessary to ensure continued performance of the TNF-XI packaging.

8.2.3 Subsystem Maintenance

8.2.3.1 Fasteners

The TNF-XI package does not contain any fasteners that require maintenance.

8.2.3.2 Seals

Seals are to be replaced every 3 years if necessary.

8.2.4 Valves, Rupture Disks and Gaskets on Containment Vessel

8.2.4.1 Valves

The TNF-XI package does not contain any valves.

8.2.4.2 Rupture Disks

The TNF-XI package does not contain any rupture disks.

8.2.4.3 Gaskets

8.2.5 Shielding

The TNF-XI package does not contain any biological shielding.

8.2.6 Thermal

No thermal tests are necessary to ensure continued performance of the TNF-XI packaging.

8.3 Appendix A

Transnucleaire Specification 12986-A-7E issue 6

Specification for Series Production of Phenolic Foam Components

Note: This appendix contains proprietary information and is withheld from public disclosure.

8.4 Appendix B

Transnucleaire BORA Resin Data Sheet

12986-R-08, Revision 2, 28/5/2002

Note: This appendix contains proprietary information and is withheld from public disclosure.

8.5 Appendix C

Transnucleaire BORA Resin: Homogeneity of Components

TNF-XI Test Procedure

12986-R-10, Revision 0, 3/2002

Note: This appendix contains proprietary information and is withheld from public disclosure.

CERTIFICATE NUMBER: USA/0653/AF-96, Revision 4

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